then the preferred range of the high-conductivity film thickness falls between 0.5 nanometers and 4 nanometers or so, more preferably between 0.5 nanometer and 3 nanometers or so in terms of the 10 microohm centimeter Cu; when Ms×t of the free layer is 3.6 nanometer Tesla and the thickness of the CoFe film is 2 nanometers, then the preferred range of the high-conductivity film thickness falls between 0.5 nanometer and 4 nanometers or so, more preferably between 1 nanometers and 3.5 nanometers or so in terms of Cu; when Ms×t of the free layer is 2.7 nanometer Tesla and the thickness of the CoFe film is 1.5 nanometers, then the preferred range of the high-conductivity film thickness falls between 0.5 nanometers and 4 nanometers or so, more preferably between 2 nanometers and 4.5 nanometers or so in terms of Cu; and when Ms×t of the free layer is 1.8 nanometer Tesla and the thickness of the CoFe film is 1 nanometer, then the preferred range of the high-conductivity film thickness falls between 0.5 nanometers and 4 nanometers or so, more preferably between 2 nanometers and 4 nanometers or so in terms of Cu.

In (8-1) IrMn is used as the antiferromagnetic film; while in (8-2), PtMn is used as the same. Using PtMn is more advantageous in that the thermal stability for MR is much more improved and the output is much more increased. This is the same as in the case of the NiFe/Co(Fe) free layer. However, PtMn is problematic in that Hin will readily increase.

Therefore, for good bias point control, either the measure of more reducing the current magnetic field Hcu or the measure of more increasing Hpin will be needed for PtMn than for IrMn. For reducing Hcu, σt in the high-conductivity layer may be increased, or that is, the thickness of the high-conductivity layer may be increased. Because of large Hin, the difference in the thickness between the upper and lower pinned layer in the Synthetic AF may be increased more for PtMn than for IrMn. However, increasing the thickness of the high-conductivity layer will cause the reduction in ΔRs. Therefore, as compared with that for IrMn, it is desirable that the thickness of the high-conductivity layer may be controlled to fall between 0.5 and 3 nanometers or so in terms of Cu for PtMn. As previously mentioned herein, increasing Δt in the Synthetic AF structure is unfavorable since it increases the MR height dependence of the bias point. Therefore, as compared with that for IrMn, it is desirable that the intrinsic thickness of the pinned layer may be increased by from 0 to 1 nanometer or so in terms of CoFe for PtMn. The following variations of (8-1) and (8-2) are within the scope of the invention.

5 nanometer Ta/x nm Ru/y nm Cu/2 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/7 nm IrMn/5 nanometer Ta (8-3)

5 nanometer Ta/x nm Ru/y nm Cu/2 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/10 nm PtMn/5 nanometer Ta (8-4)

In those variations, the high-conductivity layer is of

a laminate film of Ru/Cu but not a single-layer Cu. The reasons for the laminate film are the following two.

1. CoFe magnetostriction control.

2. Hin reduction.

The CoFe magnetostriction control of 1 is to control the magnetostriction of CoFe through the distortion control of itself, as will be mentioned hereunder. Specifically, the fcc-d(111) spacing in CoFe is enlarged more than the that on simple Cu, high conductivity layer magnetostriction in the CoFe free layer is controlled to be nearly zero. The magnetostriction of $Co_{90}Fe_{10}$ (at.%) is often enlarged in the negative side in an ordinary condition. Therefore, the material to be below the Cu layer preferably has a large atomic radius than Cu. For example, Ru is preferred. In addition to this, also preferred are Re, Au, Ag, Al, Pt, Rh, Ir, Pd, etc. For the magnetostriction control, the underlayer is made to have a two-layered structure, or the CoFe composition may be varied from 90-10 at.% to any others. Concretely, employable are CoFe alloy free layers having a varying composition of from $Co_{90}Fe_{10}$ to $Co_{96}Fe_4$.

The Hin reduction of 2 is because Ru has the ability to planarize the growing film. As previously mentioned hereinabove, Hin is preferably as small as possible for good bias point designing based on Hcu and Hpin. In particular, the spacer thickness is preferably as small as possible in two